Evaluation of NEMO model of the Fraser River plume in the Strait of Georgia

Jie Liu MSc student
Supervisor: Susan Allen
September 21, 2015

Contents

1 Motivation

2 Model nowcast results

3 Data-model comparison

4 Different river treatments

5 Hindcast comparison

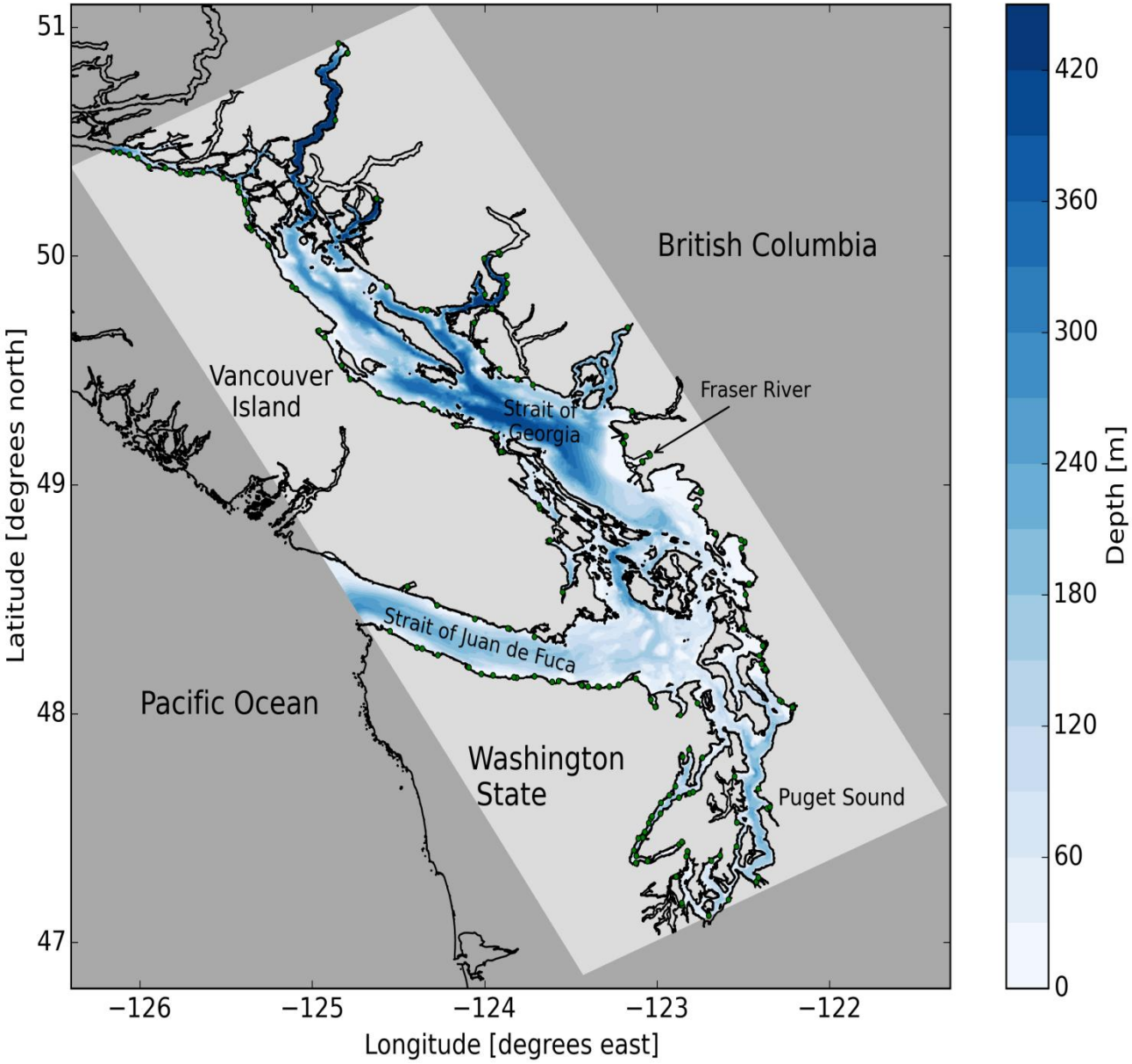
6 Summary and future work

Motivation

Image credit: WHOI

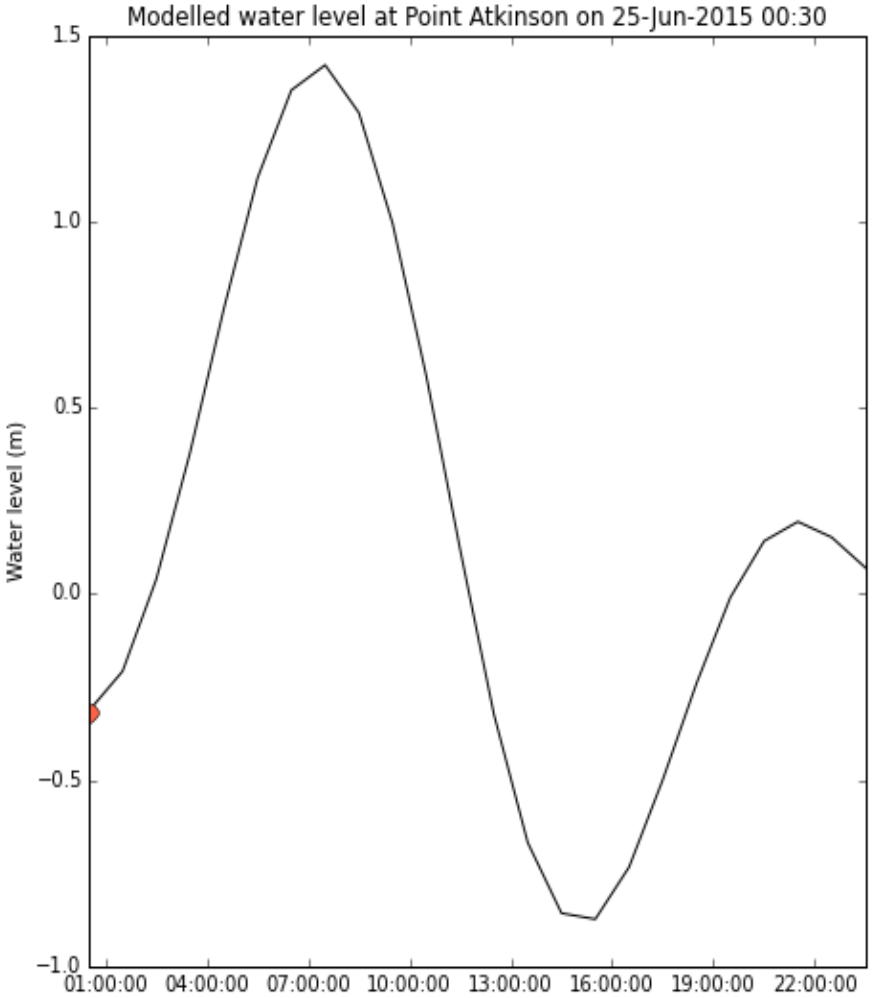
- Strait of Georgia and Salish Sea are home to a large population of residence in BC.
- Many activities in the Fraser River estuary are affected by salinity intrusions.
- Motions of Fraser River plumes influence water properties and circulation.

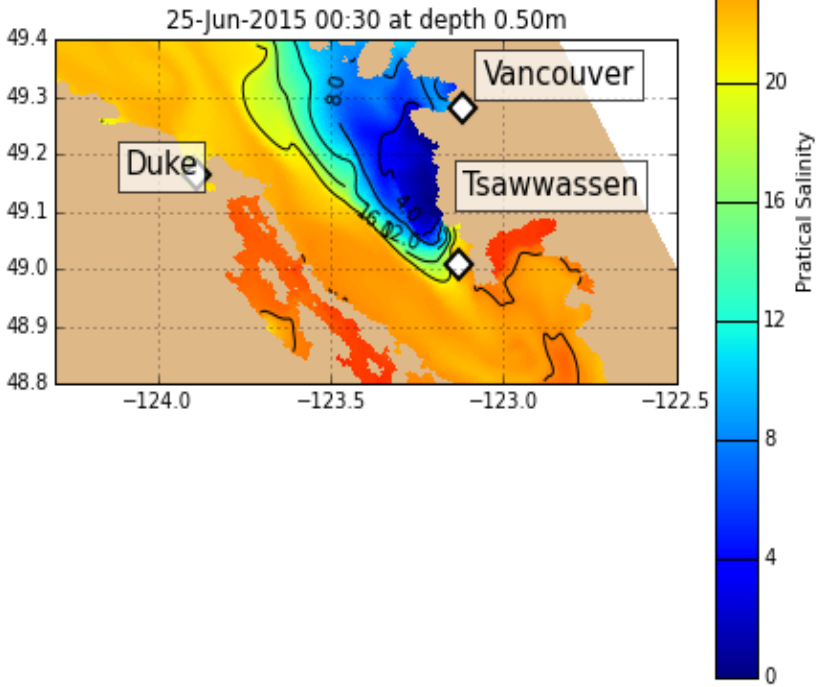
Model domain



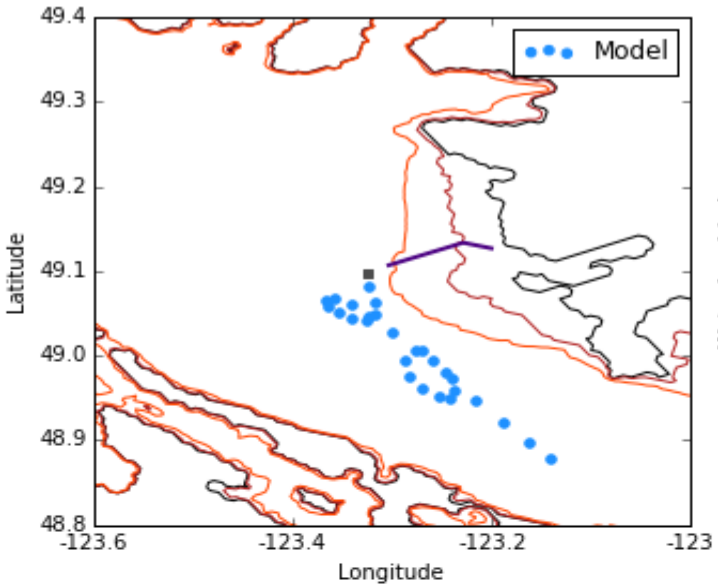
- NEMO 3.4 in regional configuration.
- 398 * 898 * 40 grid cells.
- 150 rivers parameterized.
- Produce nowcast and forecast model results.

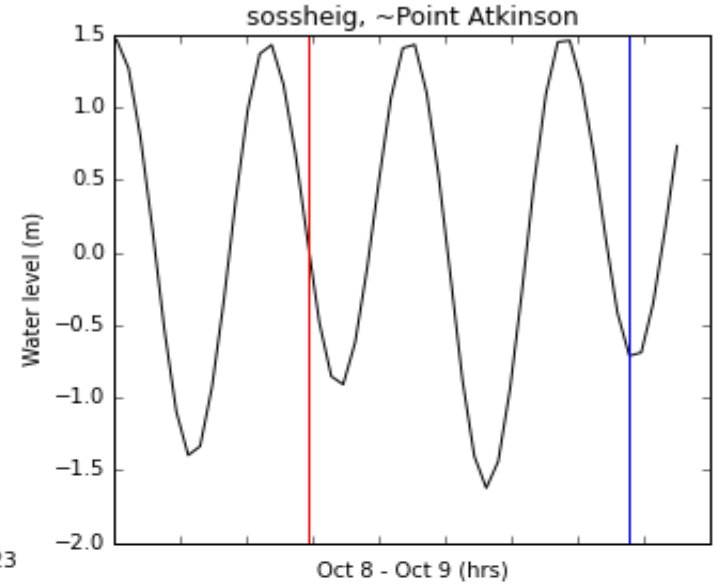
Model nowcast results

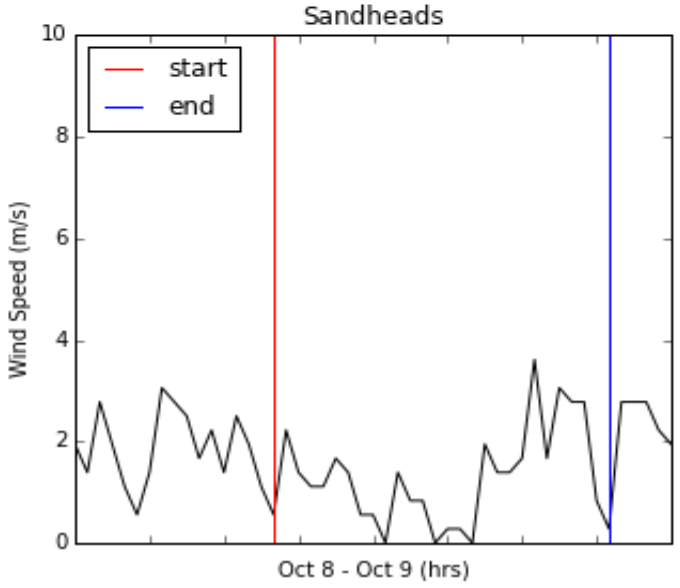


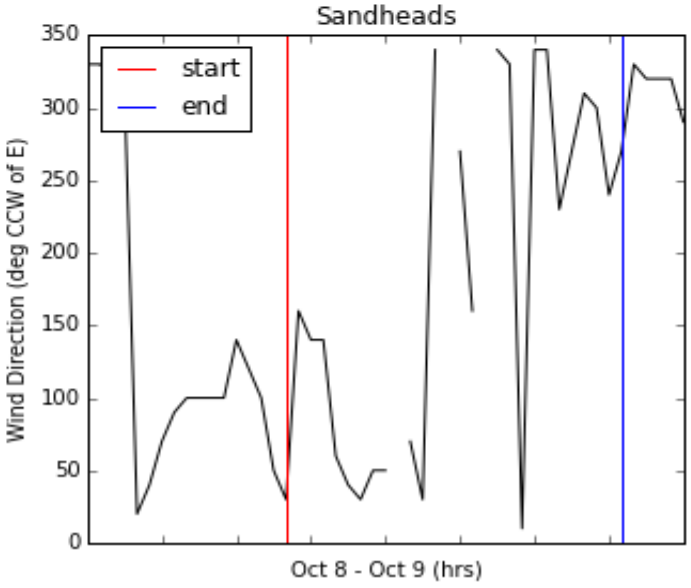


Model nowcast results + Ariane



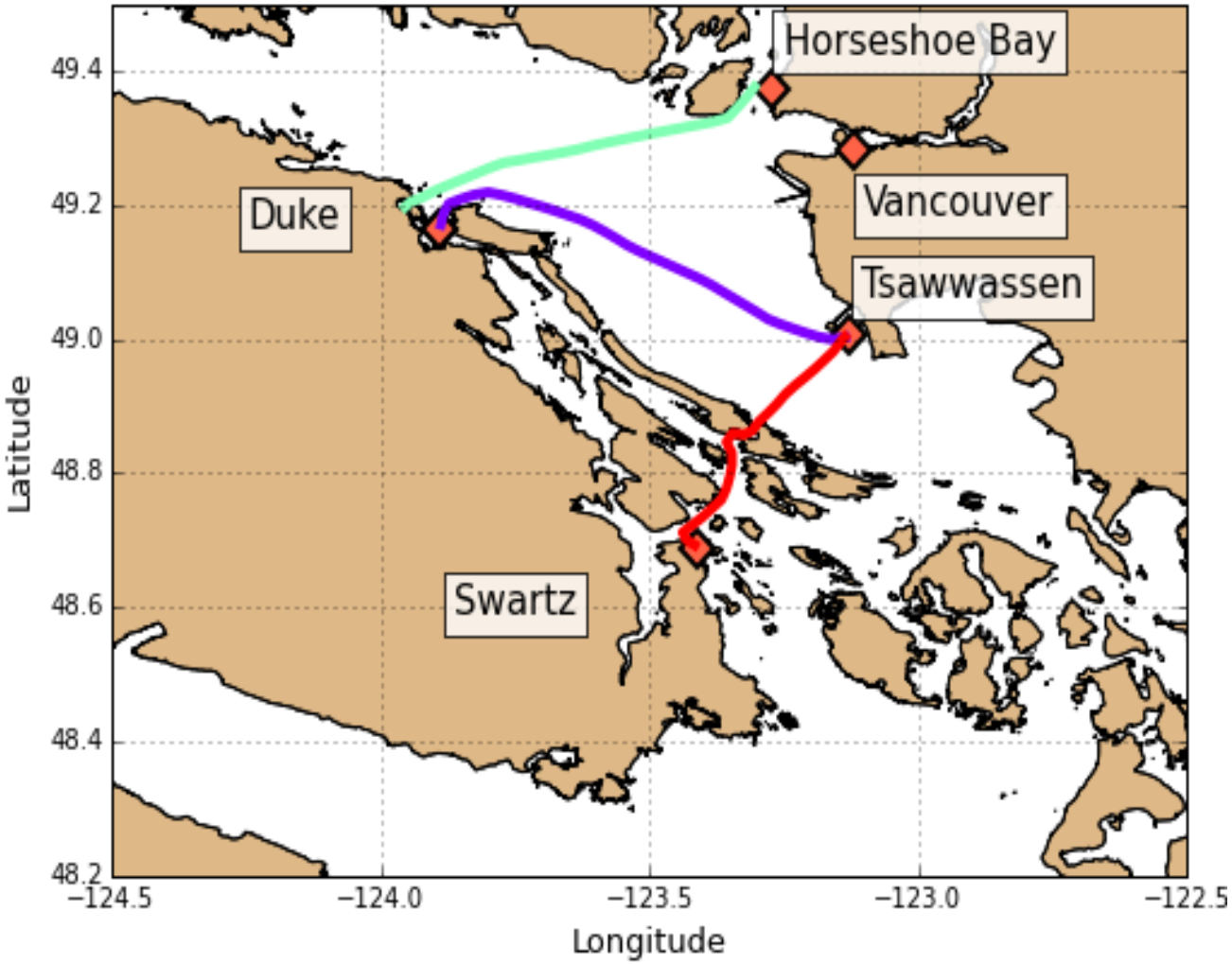






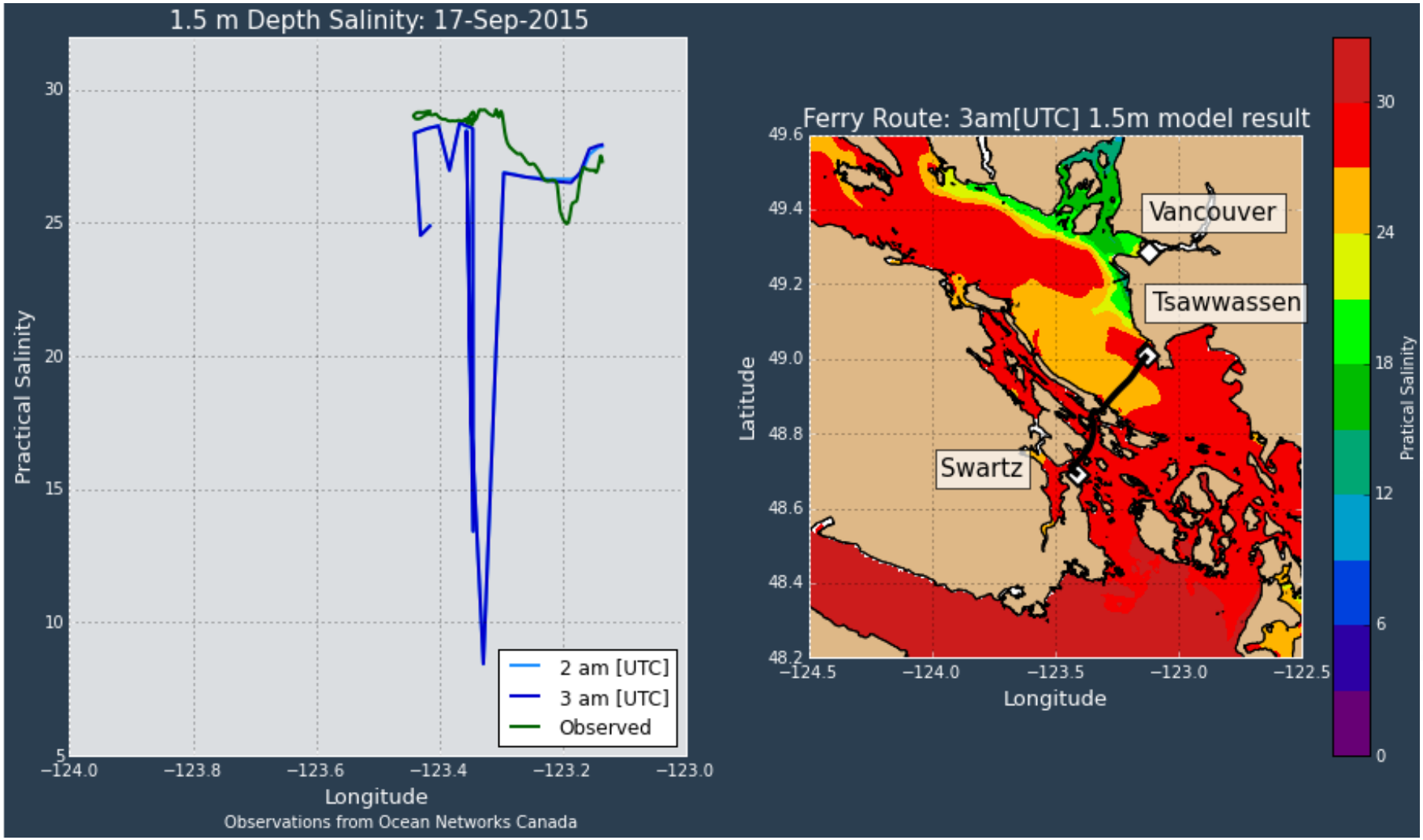
Data-model comparison

- **BC Ferry data**



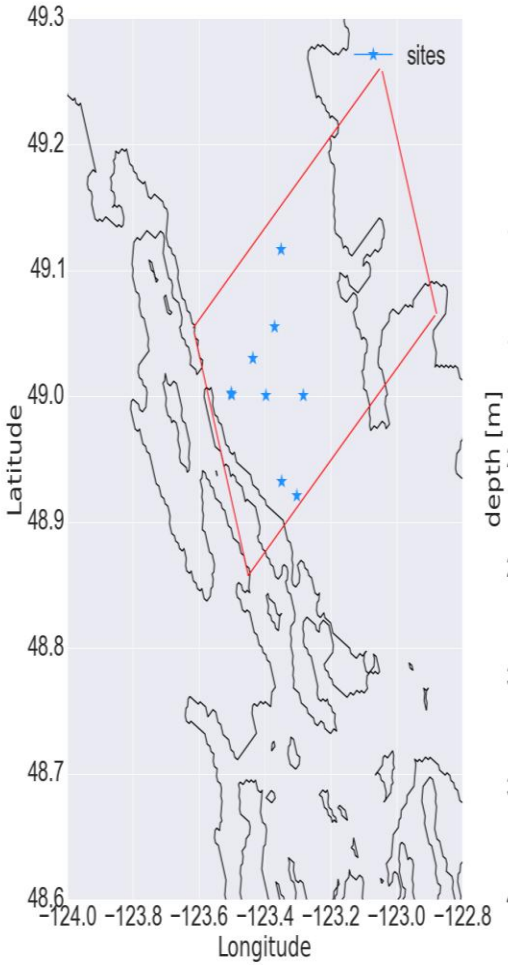
- **VENUS (Ocean Networks Canada)**
  - Tsawwassen to Duke Point
  - Nanaimo to Horseshoe Bay
  - Tsaawassen to Swarze

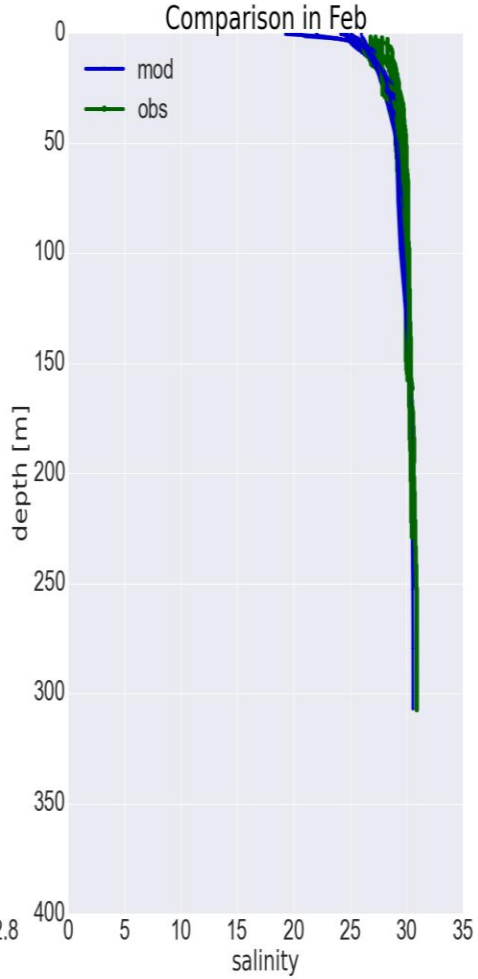
Data-model comparison

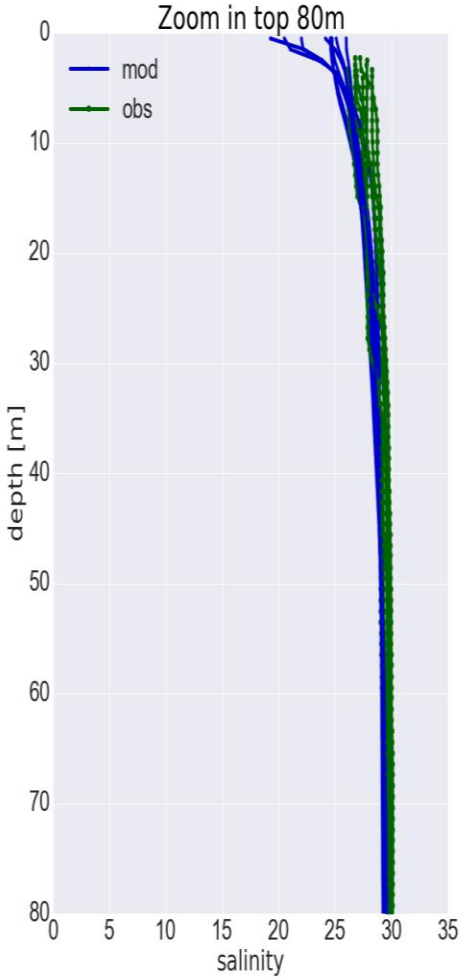


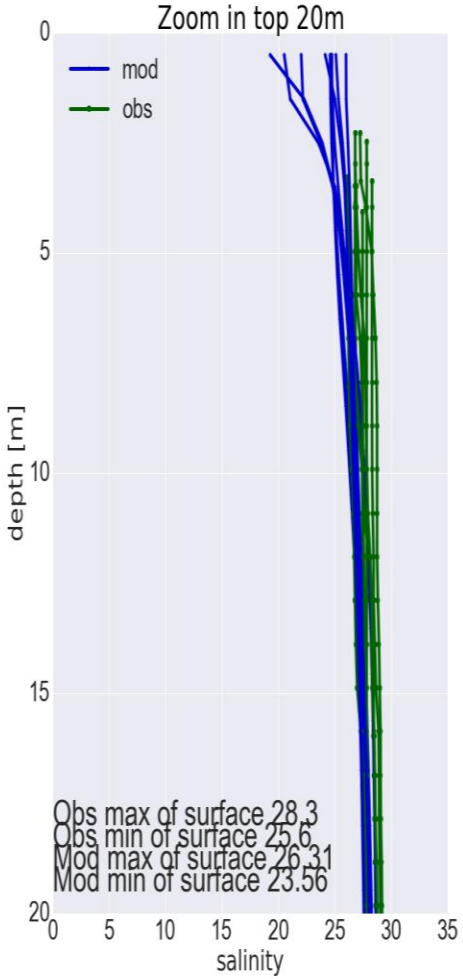
Data-model comparison

- CTD casts from Institute of Ocean Sciences



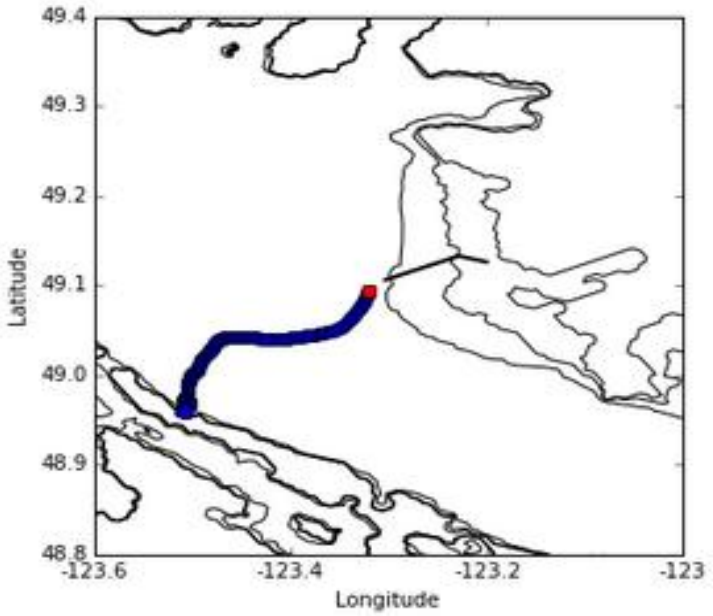


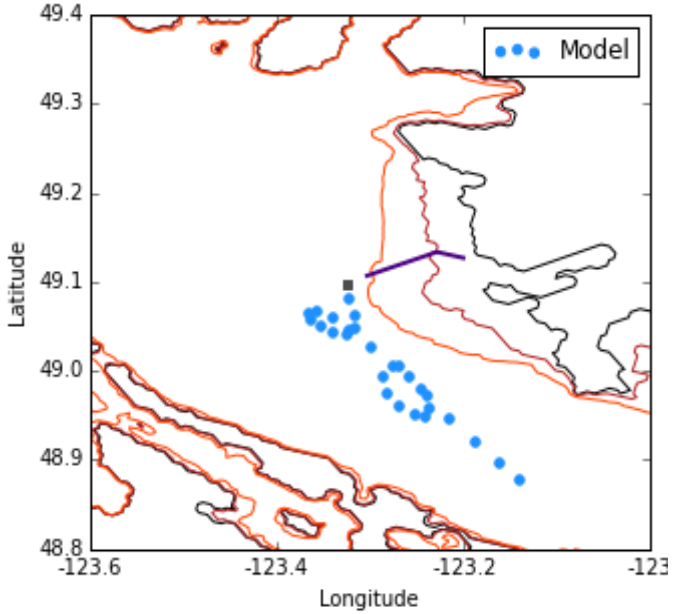




Data-model comparison

- **Drifters from Rich and Mark**





➢ Released on Oct 8, 2014 after 27 hours duration.

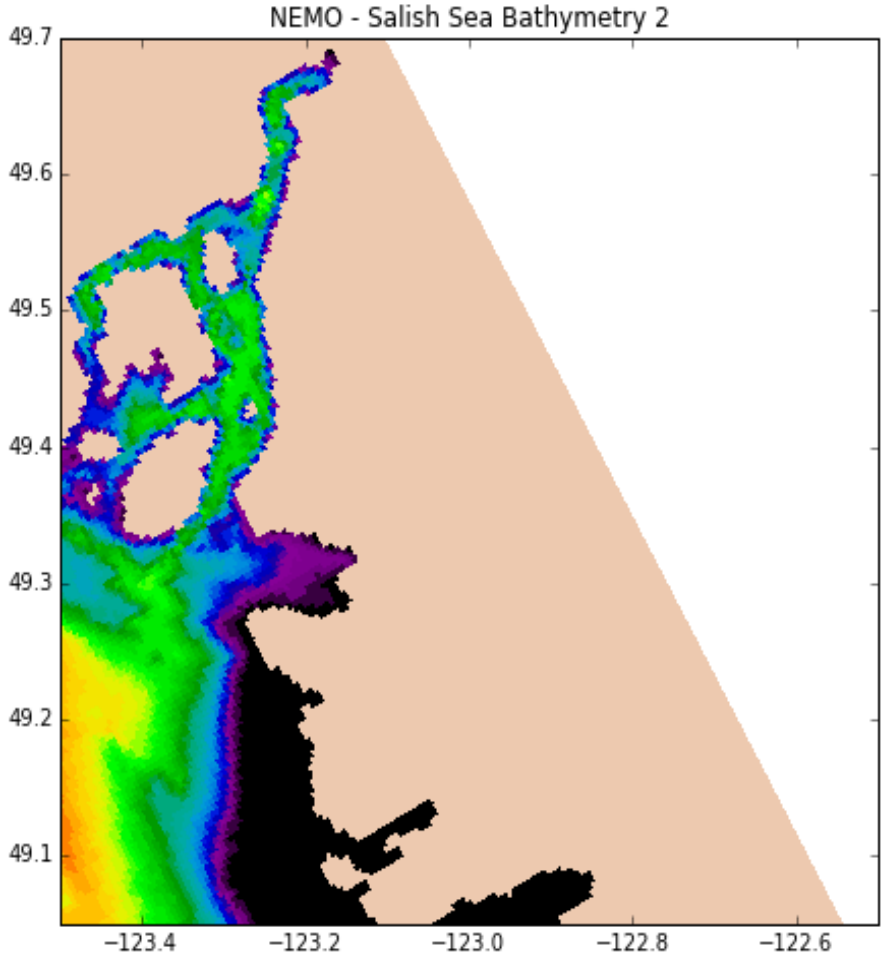
Problems for model results:

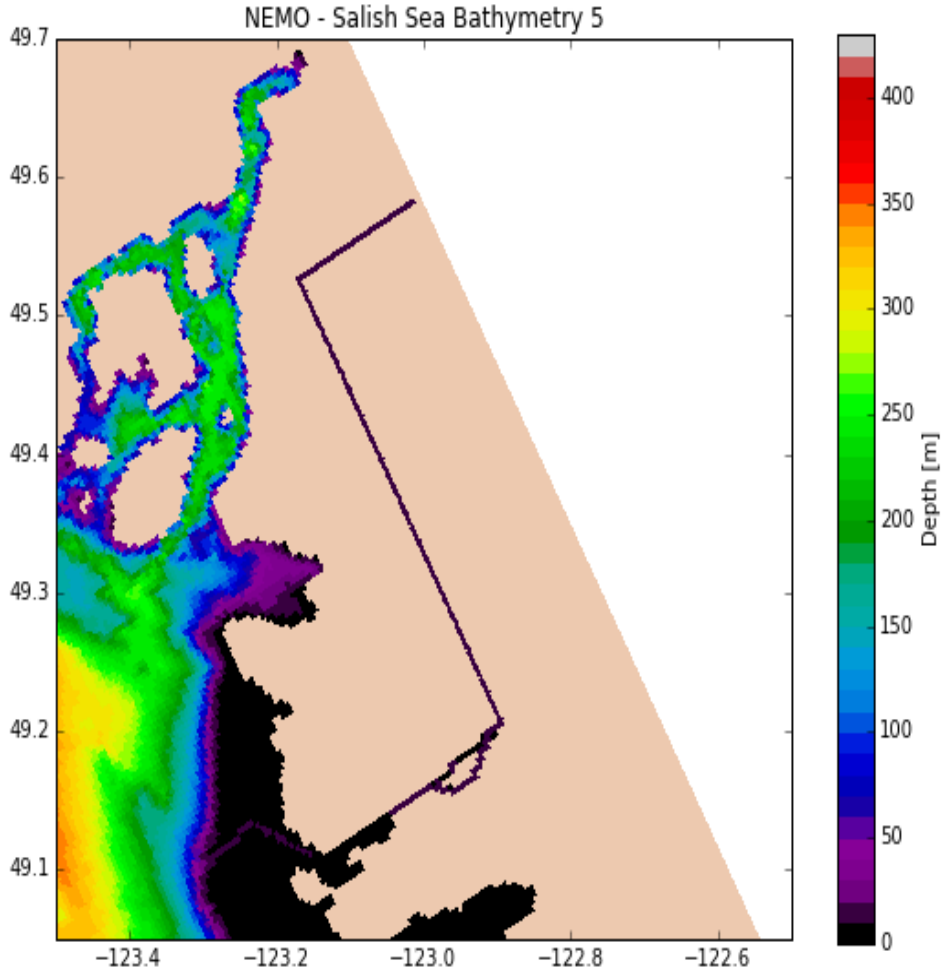
How to improve surface currents in the plume?!

1	2
☐ Too weak cross strait velocity in the model.	☐ Position northward shift for plumes in the model.

Different river treatments

- **Hypothesis 1: Too short river channel**





- Original river channel for Fraser: **bathymetry 2**
- Extended river channel for Fraser: **bathymetry 5**

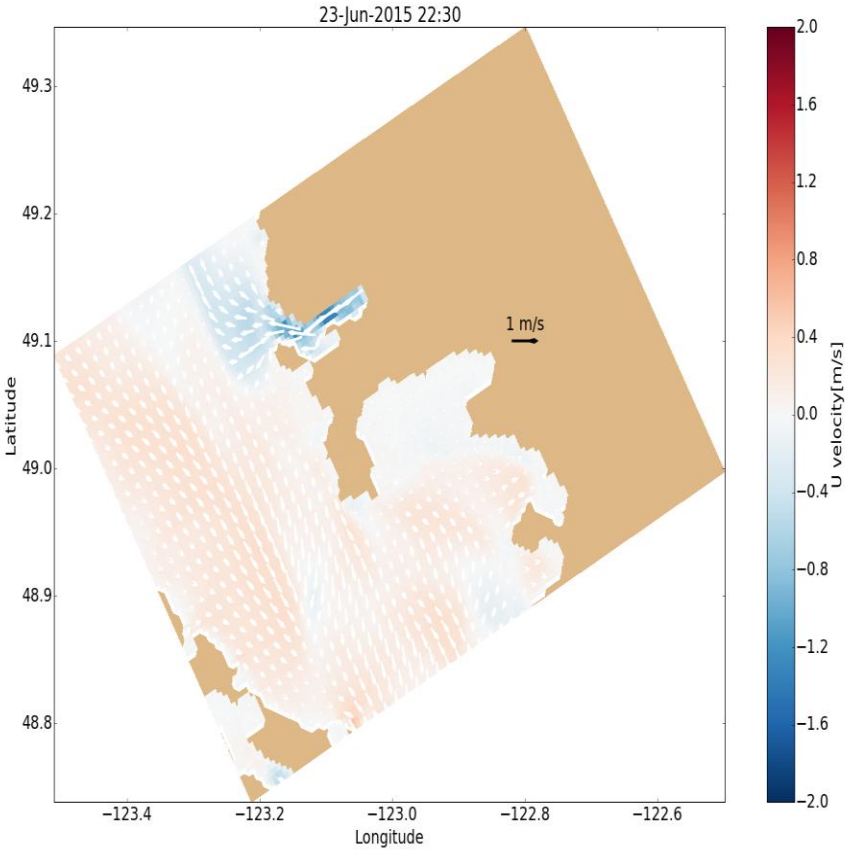
Different river treatments

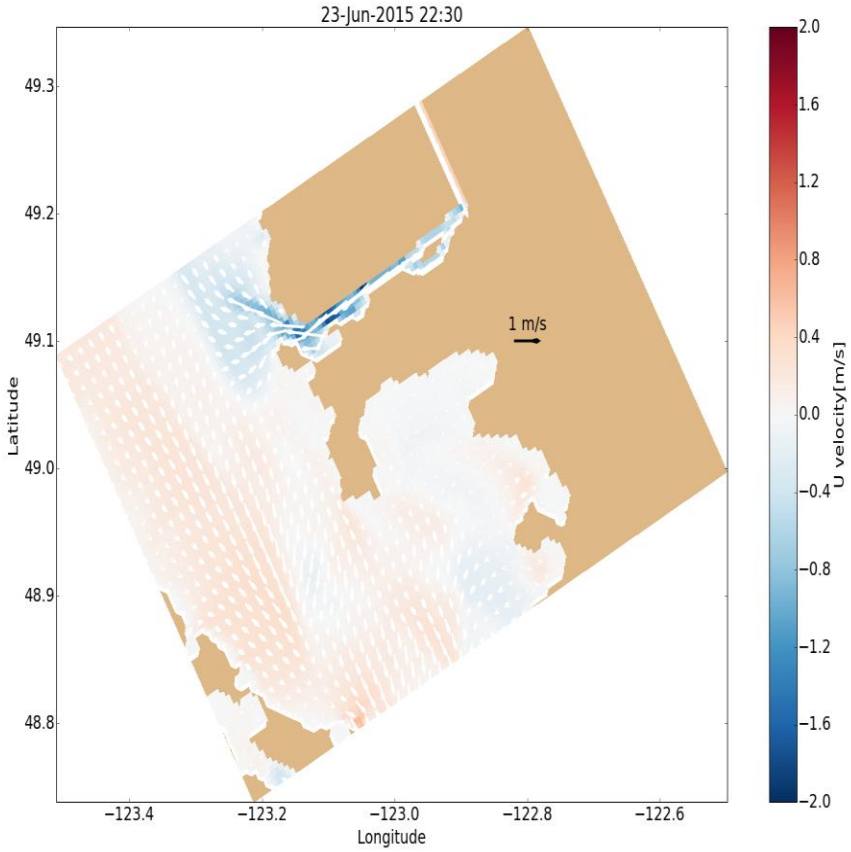
- **Model configuration for sensitivity experiments:**

  - **NEMO 3.4** version.
  - **Smoothed bathymetry 5** that includes a ‘long’ river channel to the east.
  - Minimum depth is set to 4 m, **no wetting and drying**.
  - Temperature, salinity initial conditions: **T** for new channel of **14° C**
    S after New Westminster as **0**, before as **4**.
  - Model forcing: **Climatology river runoff** of Fraser.
    8 tidal constituents forced the boundary.
    Daily operational model winds.
  - Parameters: background **vertical eddy viscosity** $1\times10^{-4}\ m^2\ s^{-1}$
    background **vertical eddy diffusivity** $1\times10^{-5}\ m^2\ s^{-1}$

Different river treatments

- **Sensitivity experiment with bathymetry 5:**



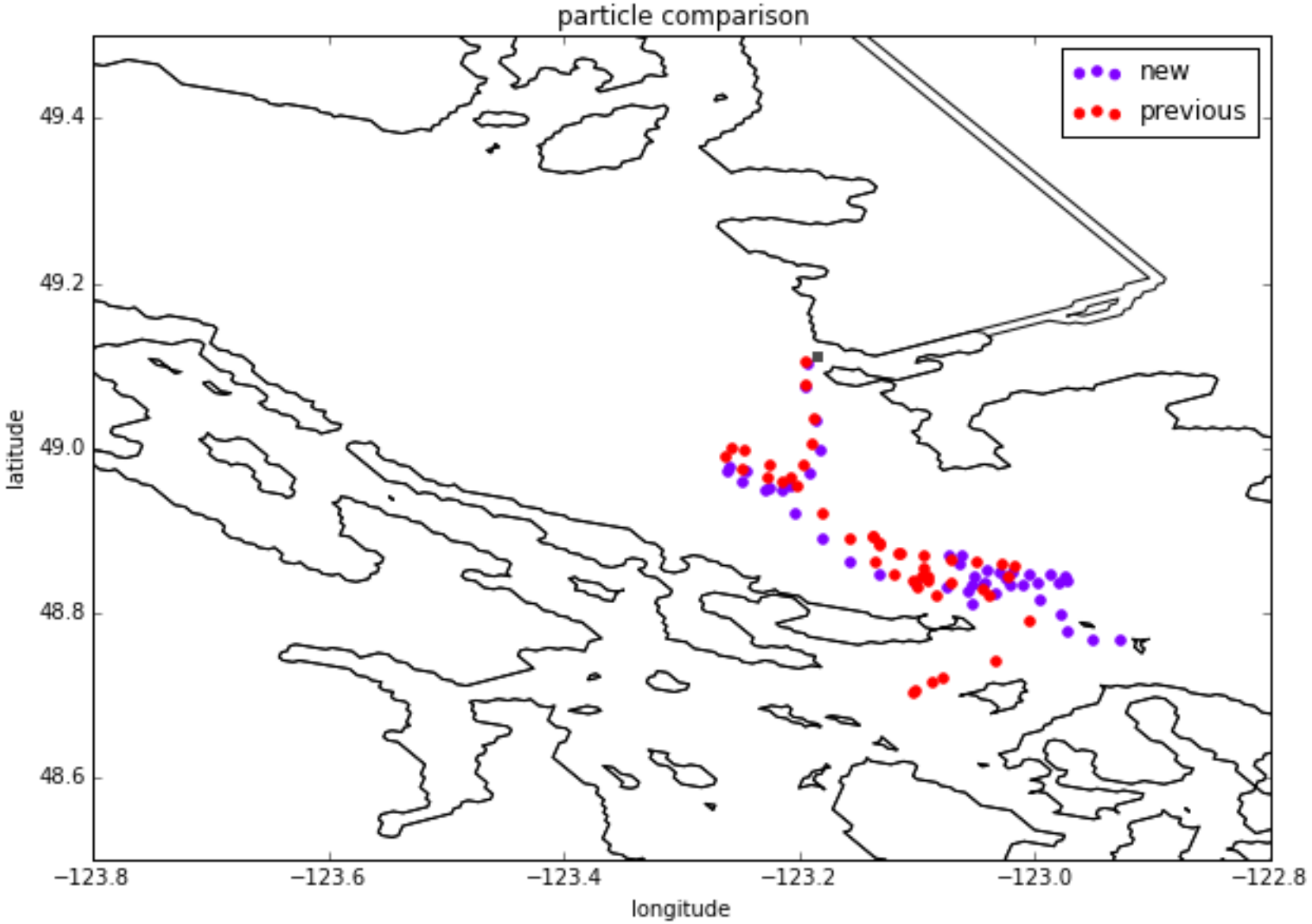


- Model nowcast results from June 15 to June 29, 2015

- 15 days simulation run from June 15 to June 29, 2015

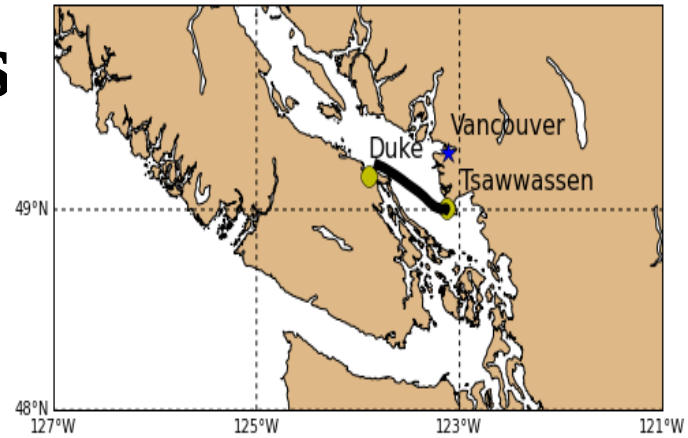
Different river treatments

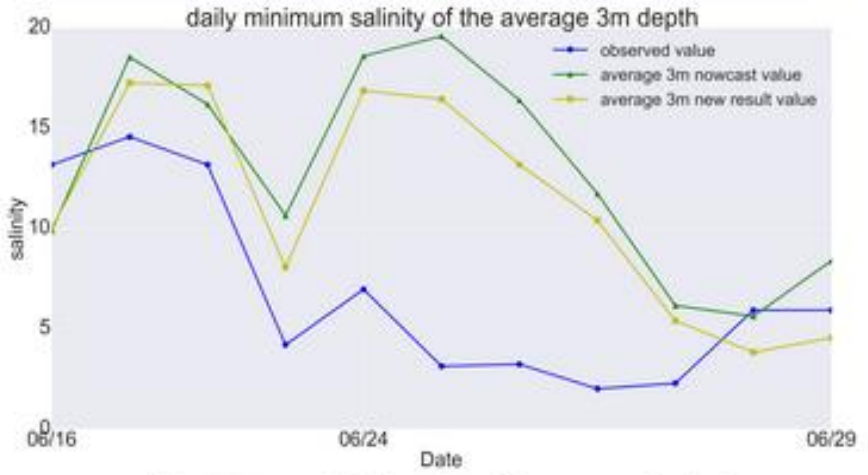
- Particle tracking for bathymetry 5 and bathymetry 2

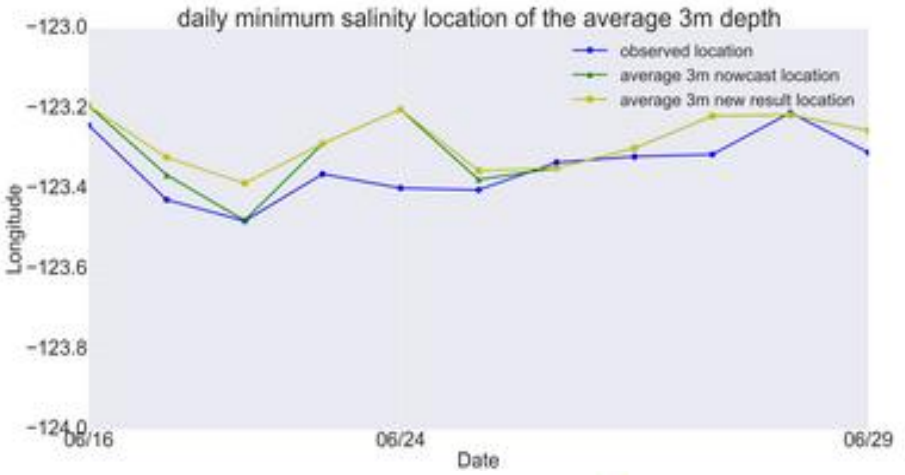


Different river treatments

- Minimum salinity value/location

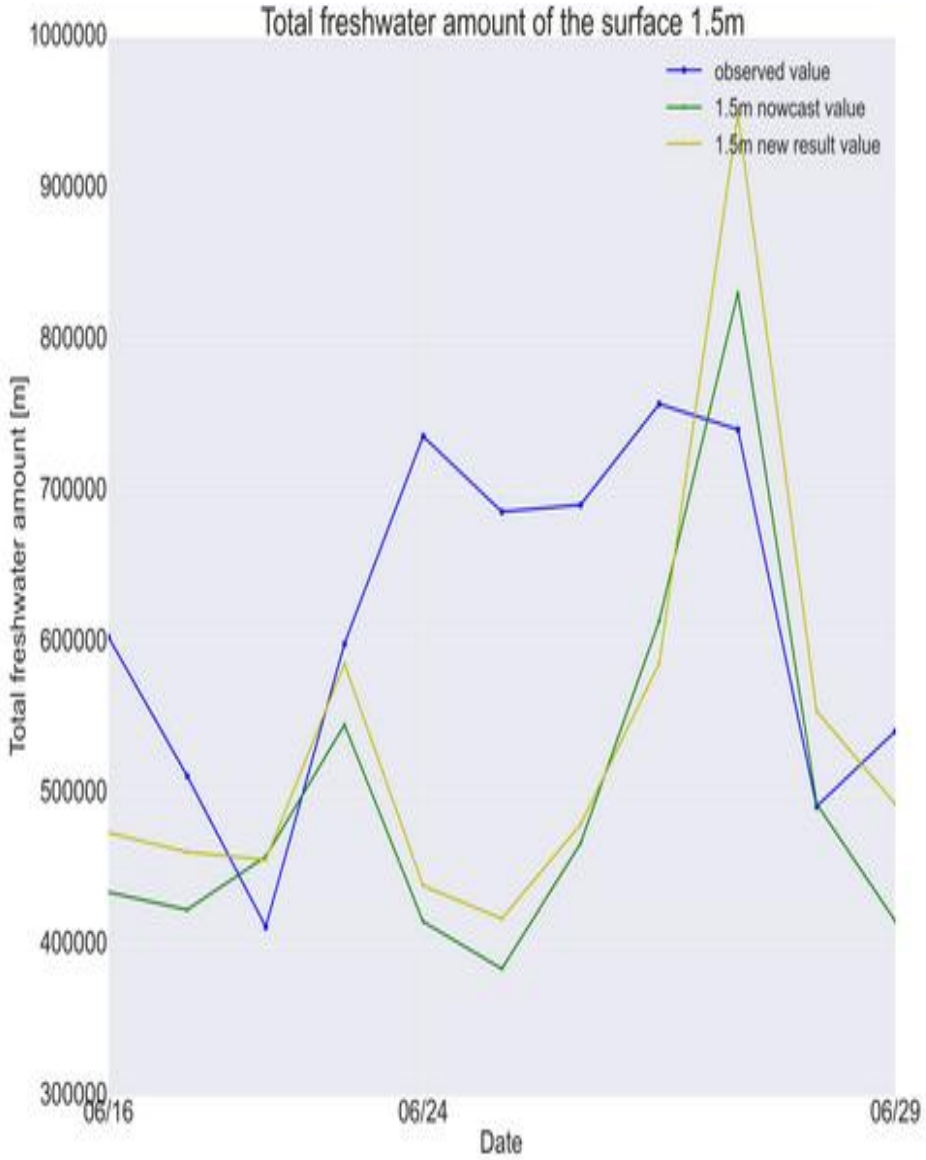


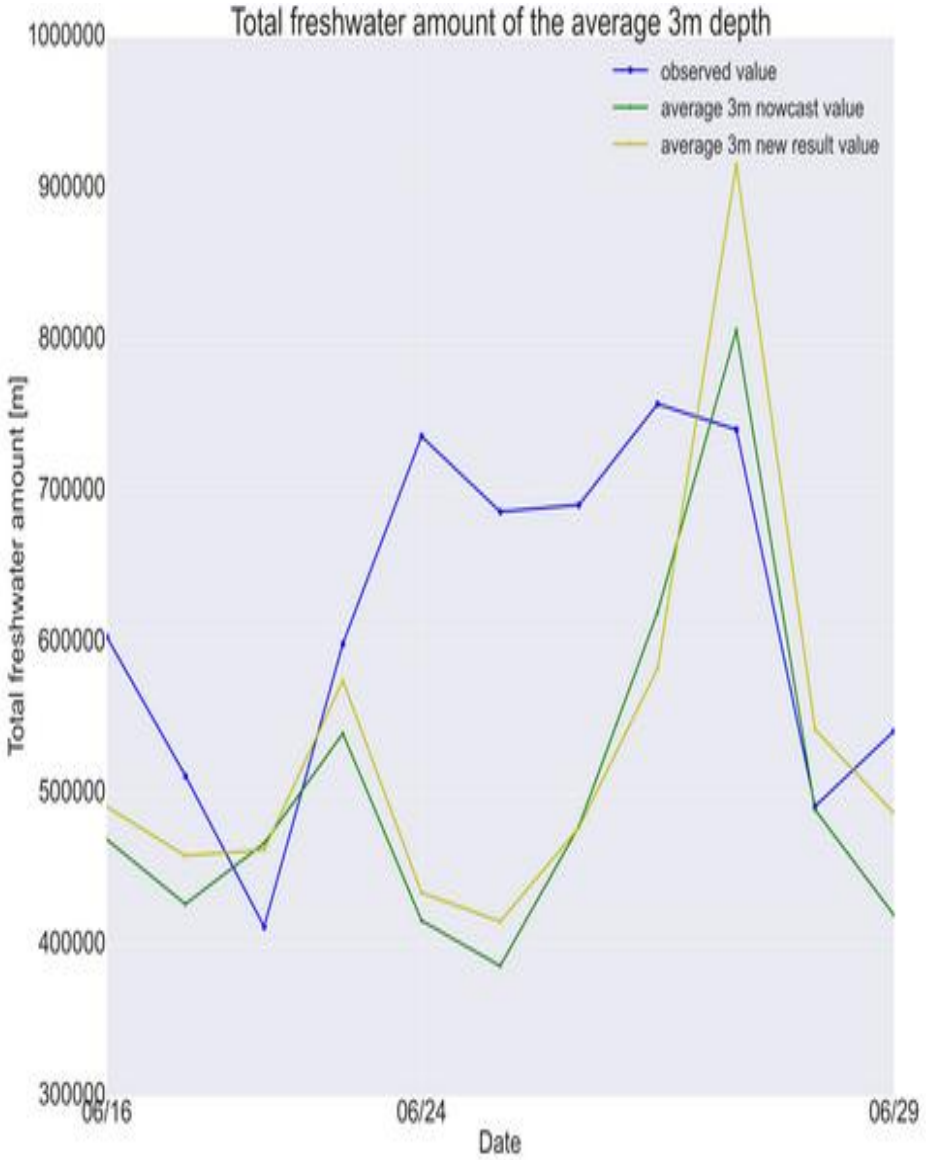




Different river treatments

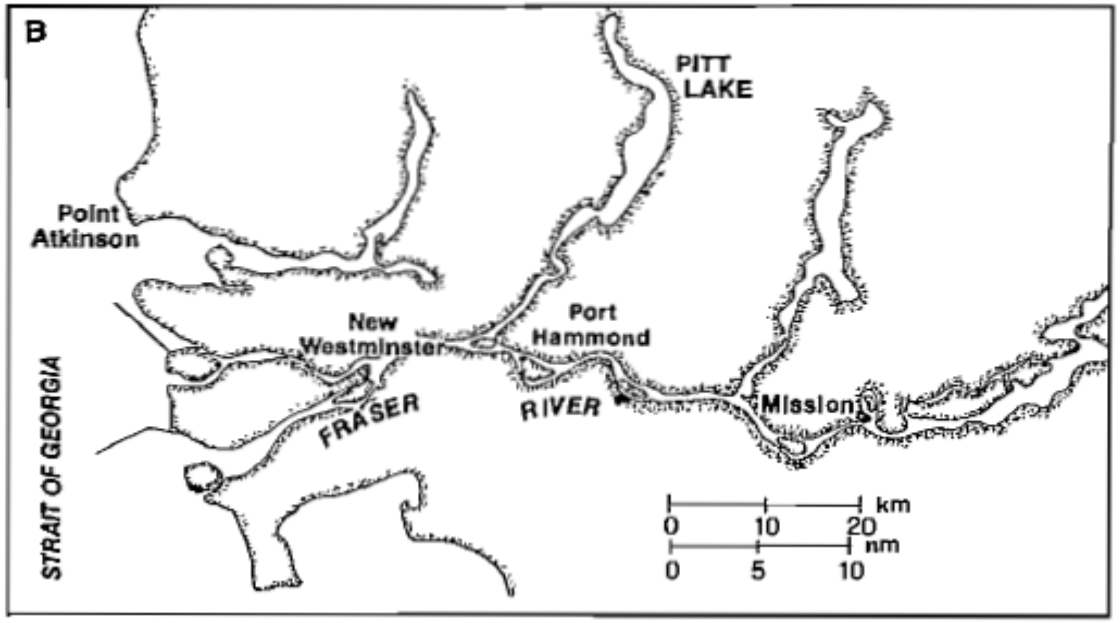
- **Freshwater amount along ferry route**





Different river treatments

- Tidal heights along Fraser River channel for bathymetry5



- Water level = Tidal height + height caused by river discharge

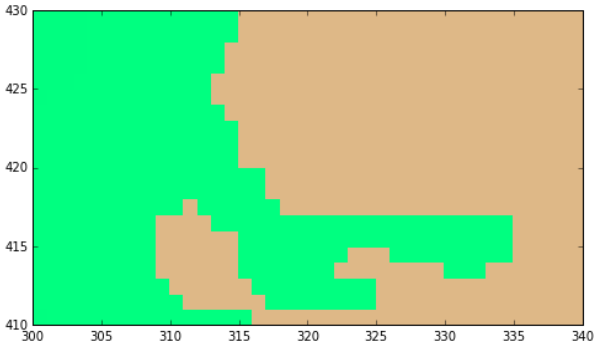
Map of river(Ages and Woollard 1976)

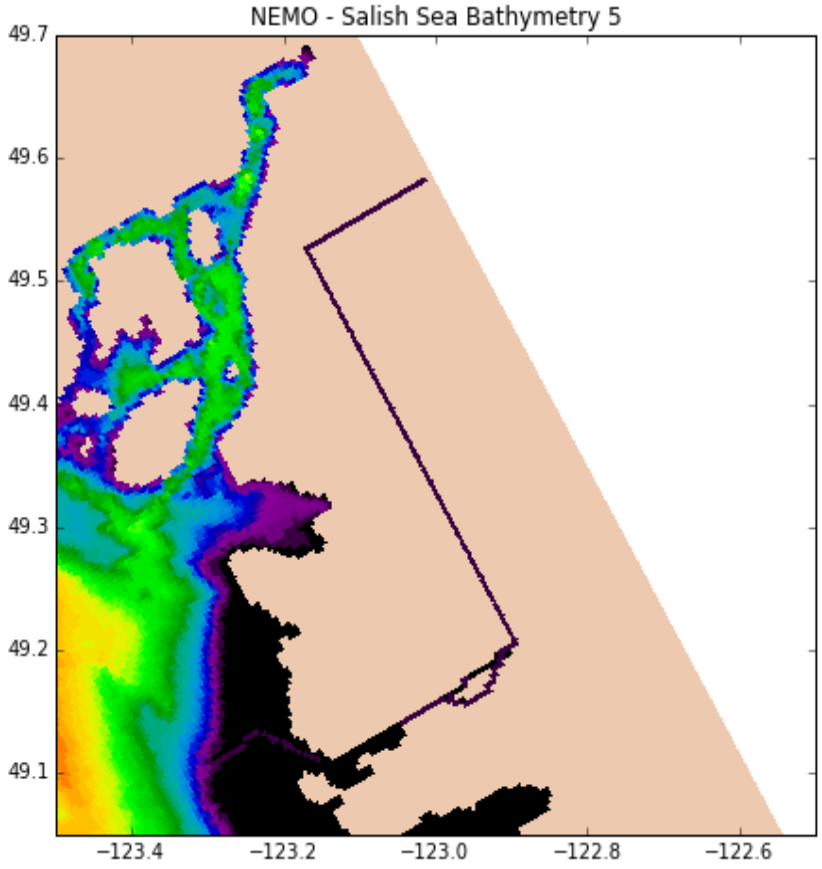
Table 2.1: Tidal amplitude comparisons inside Fraser River between extended river channel and observations

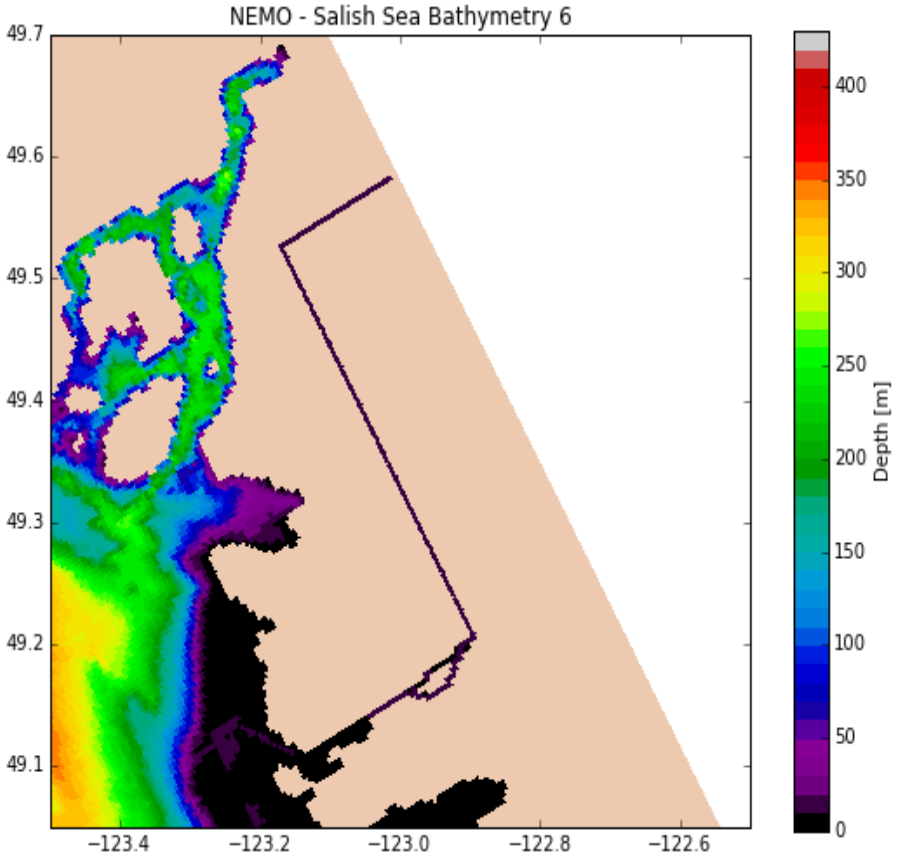
Tidal amplitude							
Station Names	Distance from mouth[km]	Observed Max Ampli-tude[m]	Observed Min Ampli-tude[m]	Observed Mean Ampli-tude[m]	Model Produced Max Ampli-tude[m]	Model Produced Min Ampli-tude[m]	Model Produced Mean Ampli-tude[m]
Steveston	1	3.49	2.10	2.88	3.73	2.03	2.91
Deas Island Channel	18	3.05	1.85	2.58	1.46	1.01	1.27
New Westminster	36	2.28	1.43	1.91	0.84	0.57	0.71
Mission	52	0.37	0.24	0.31	0.84	0.57	0.70

Different river treatments

- **Hypothesis 2: Too shallow river channel**







➢ Extended river channel for Fraser: **bathymetry 5**

➢ Extended and deepened river channel for Fraser: **bathymetry 6**

Different river treatments

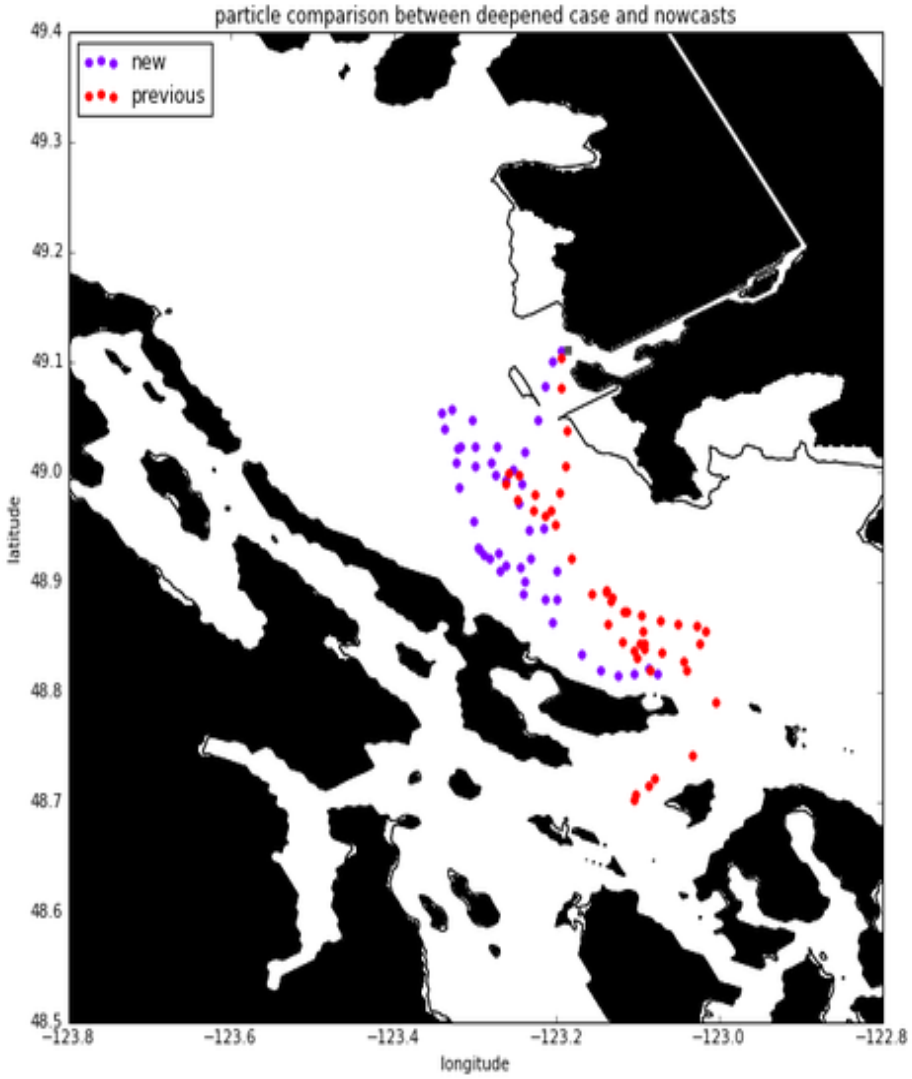
- **Tidal heights along Fraser River channel for bathymetry6:**

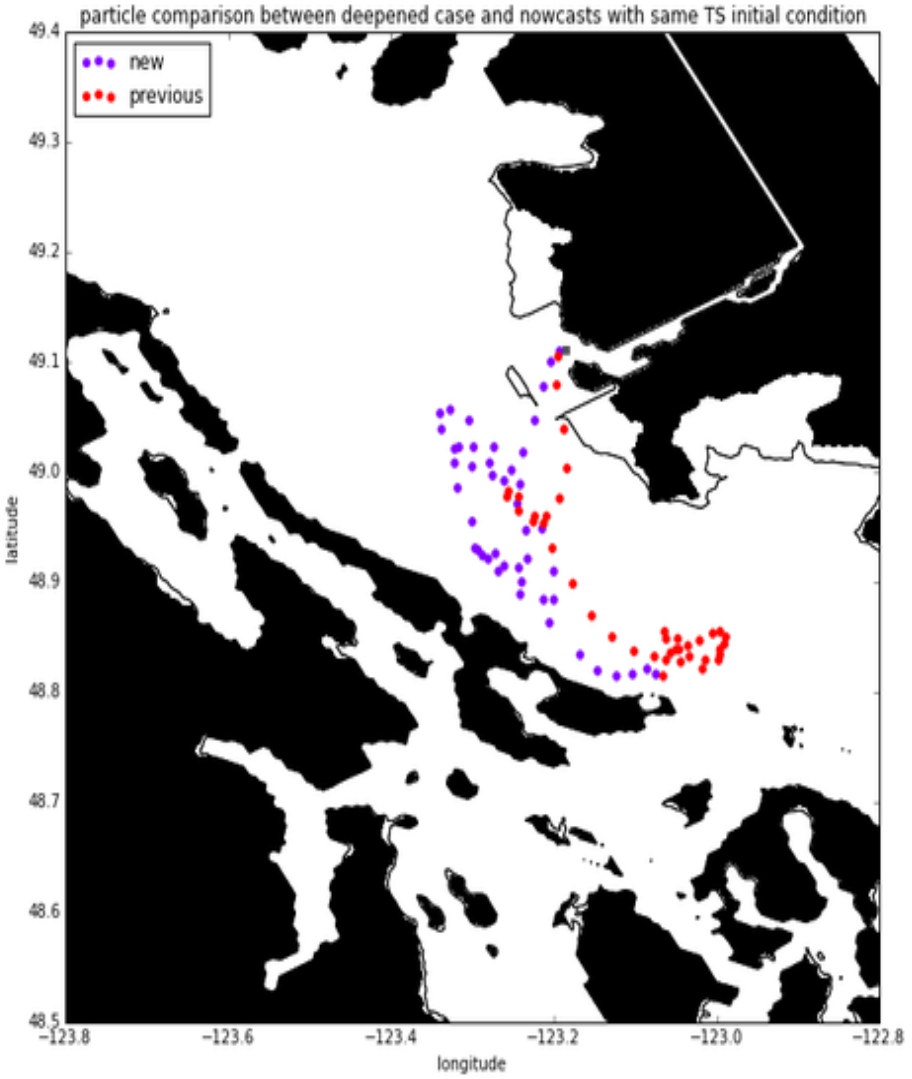
Table 2.2: Tidal amplitude comparisons inside Fraser River between deepened river channel and observations

Tidal amplitude							
Station Names	Distance from mouth[km]	Observed Max Amplitude[m]	Observed Min Amplitude[m]	Observed Mean Amplitude[m]	Model Produced Max Amplitude[m]	Model Produced Min Amplitude[m]	Model Produced Mean Amplitude[m]
Steveston	1	3.49	2.10	2.88	3.72	2.03	2.89
Deas Island Channel	18	3.05	1.85	2.58	3.55	2.04	2.80
New Westminster	36	2.28	1.43	1.91	3.02	1.78	2.42
Mission	52	0.37	0.24	0.31	3.00	1.71	2.37

Different river treatments

- **bathymetry 6:**





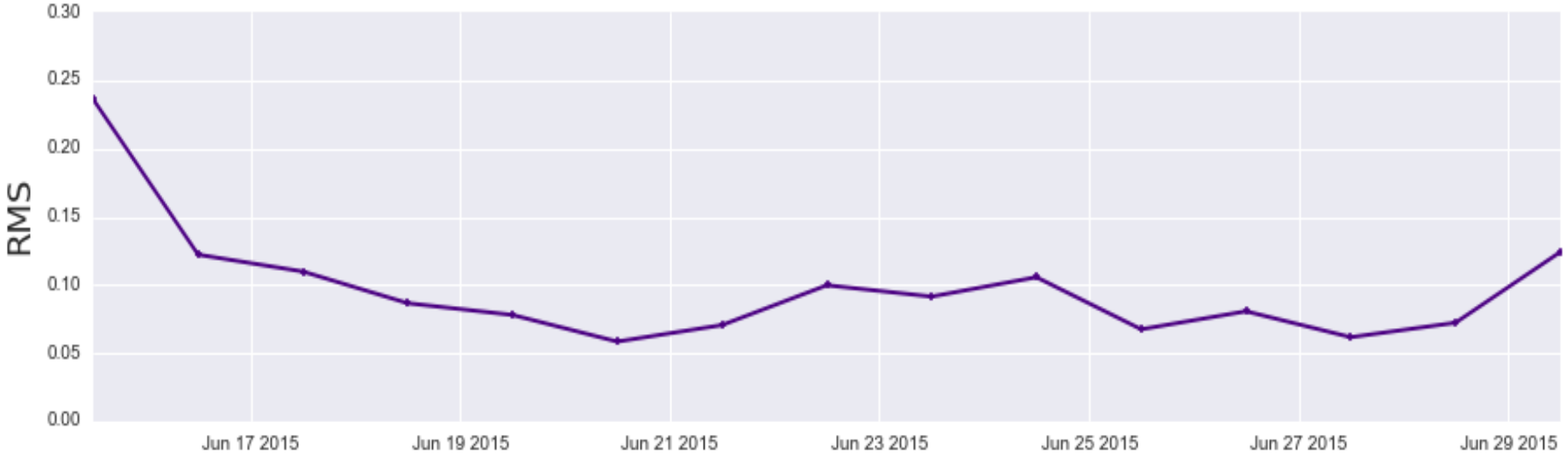
Hindcast comparison

- **Spin-up preparation for hindcast simulation**

$$\mathrm{RMS(t)} = \sqrt{\frac{\sum_{i=1}^{24}\left(u_{now}(t,i) - u_{\mathrm{mine}}(t,i)\right)^2 + \sum_{i=1}^{24}\left(v_{now}(t,i) - v_{\mathrm{min}\,e}(t,i)\right)^2}{24}}$$

$u_{now}\ v_{now}$: velocity of Doug's nowcasts at Sandheads

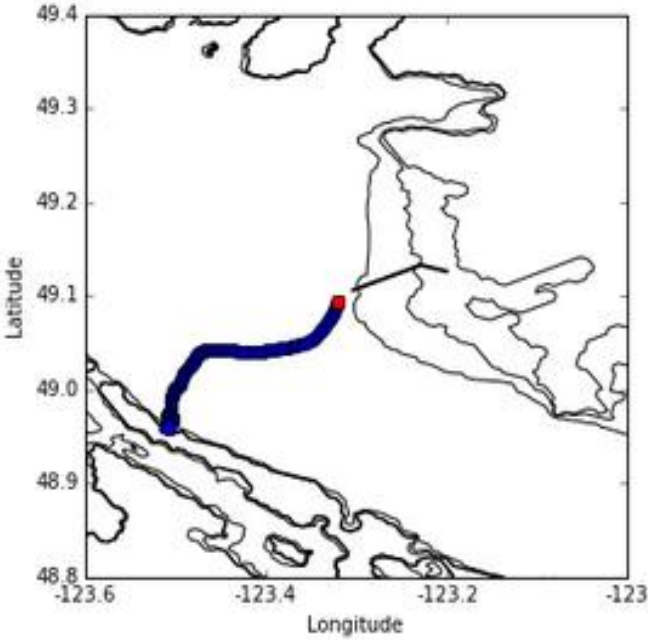
$u_{\mathrm{min}\,e}\ v_{\mathrm{min}\,e}$: velocity of my nowcasts from cold start at Sandheads

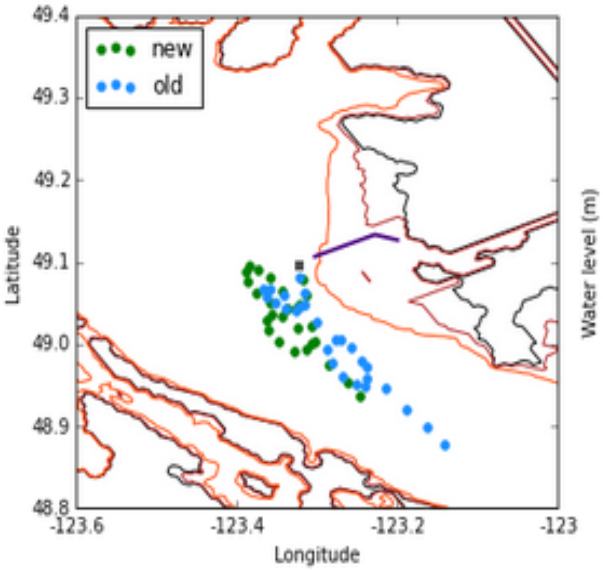


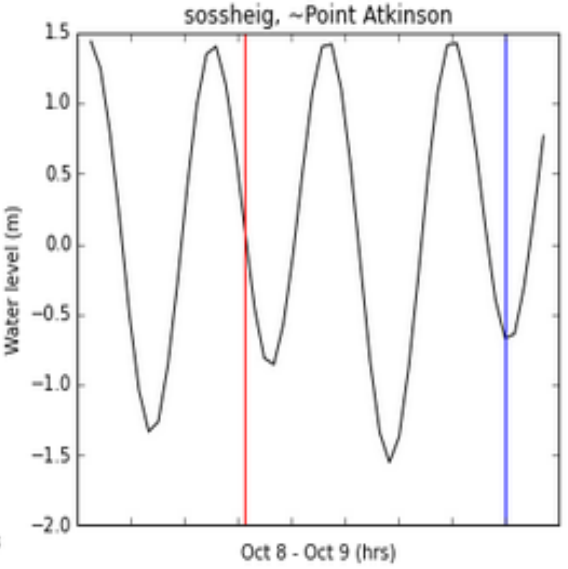
Hindcast comparison

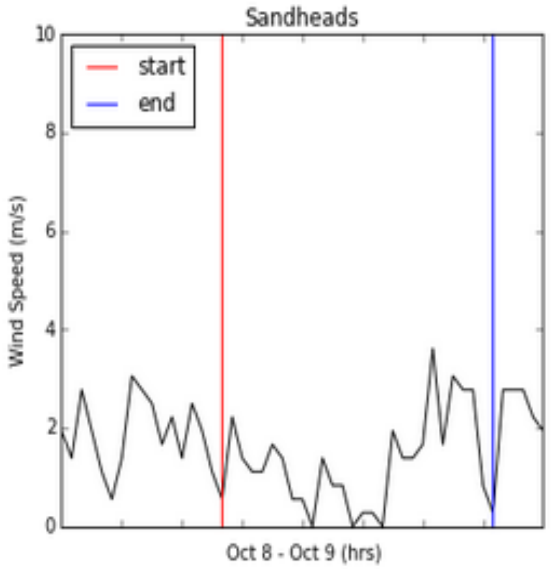
- **Smoothed bathymetry 6 and daily Fraser runoff**

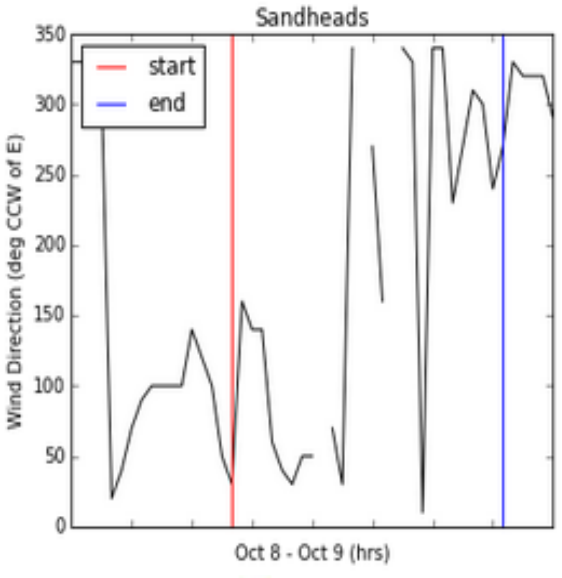
- Spin-up run: Sep 25-Oct 7
- Hindcast run: Oct 8-10





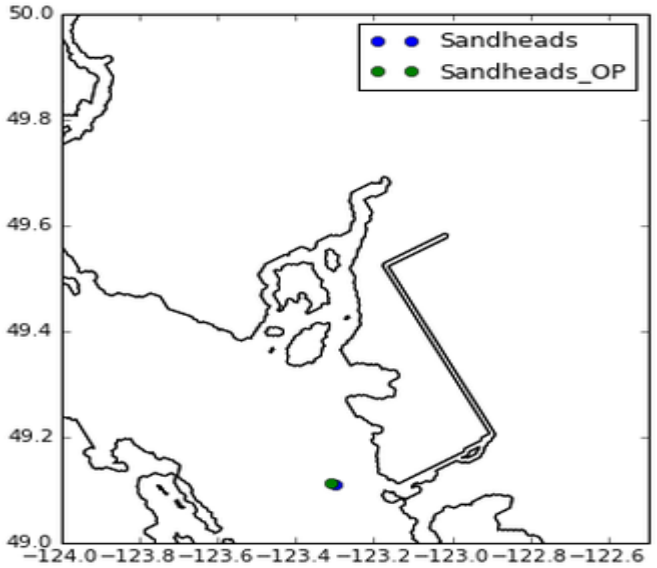


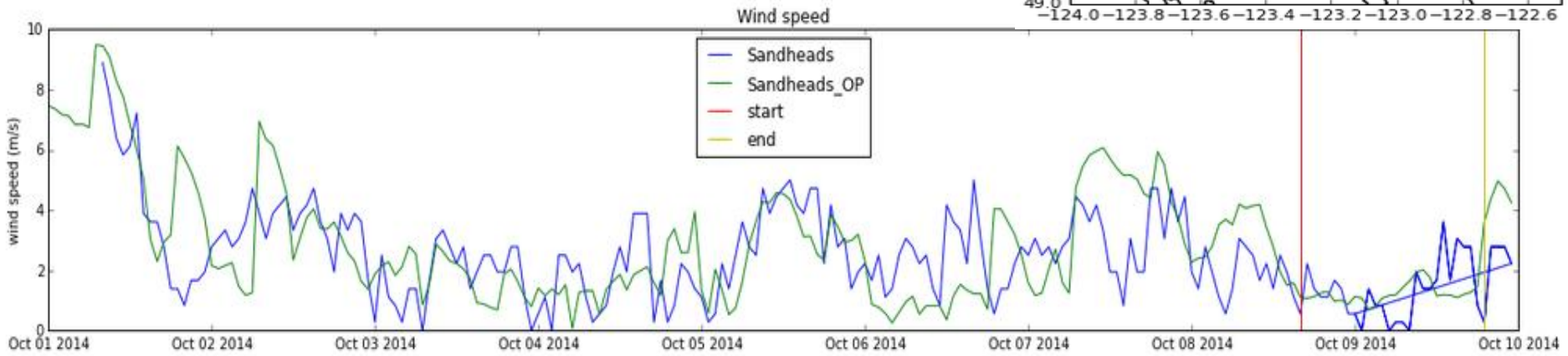


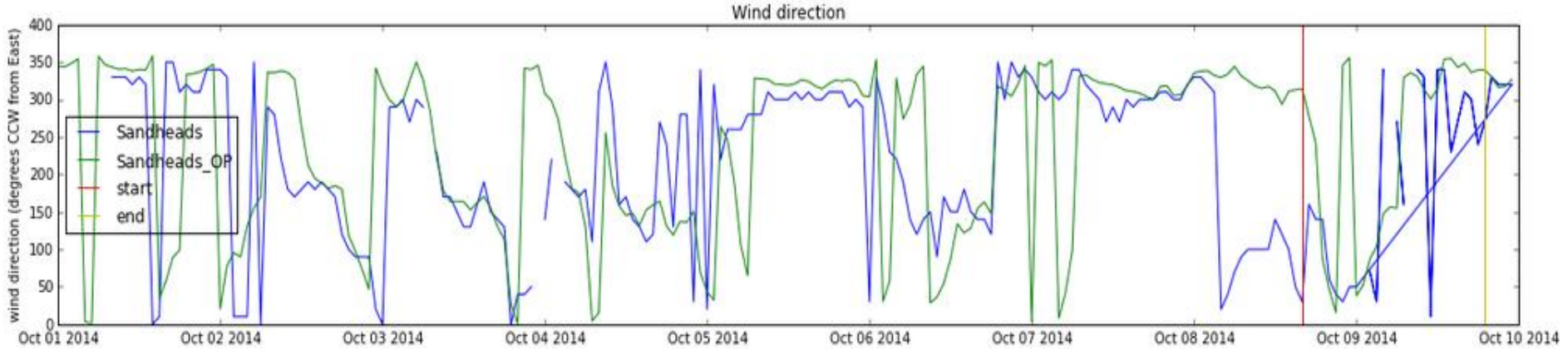


Hindcast comparison

- Wind information

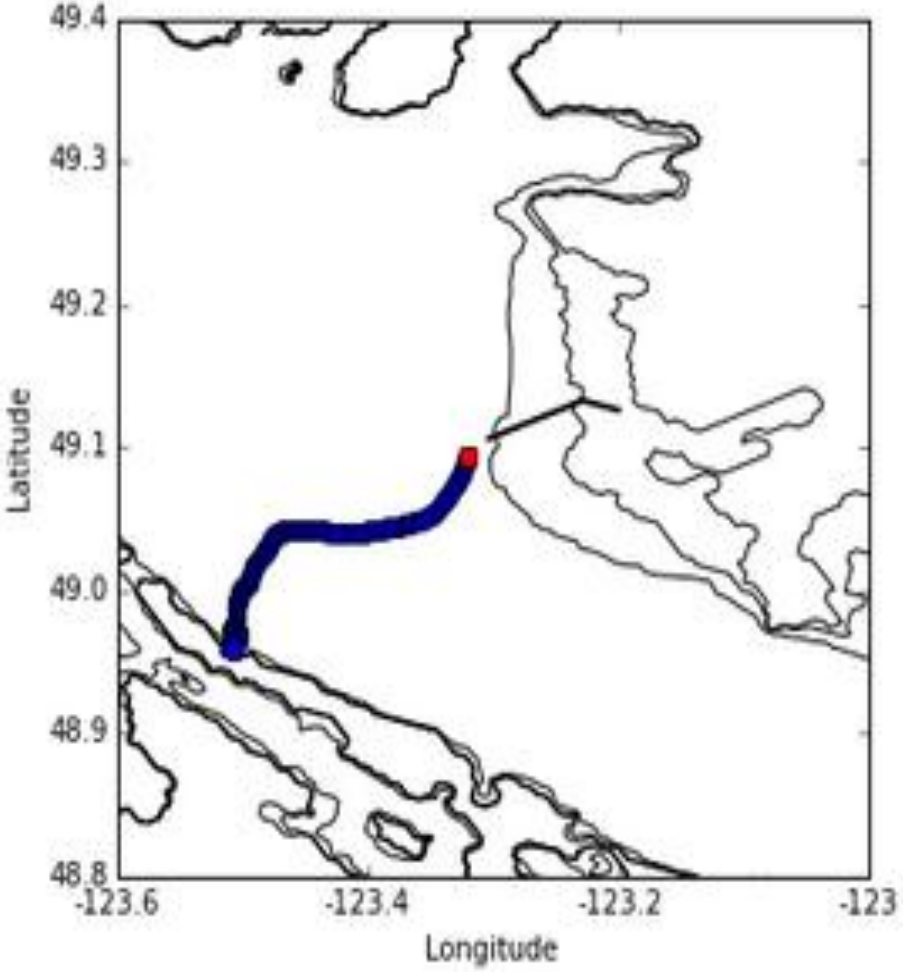


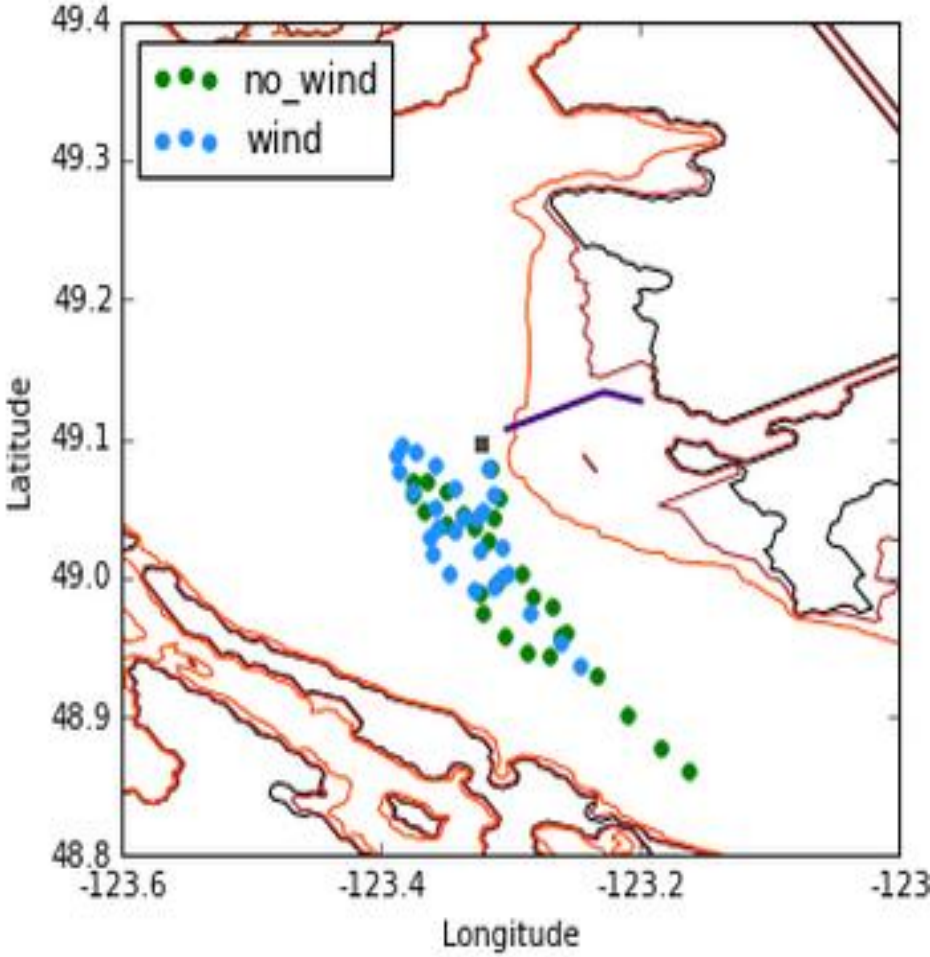




Hindcast comparison

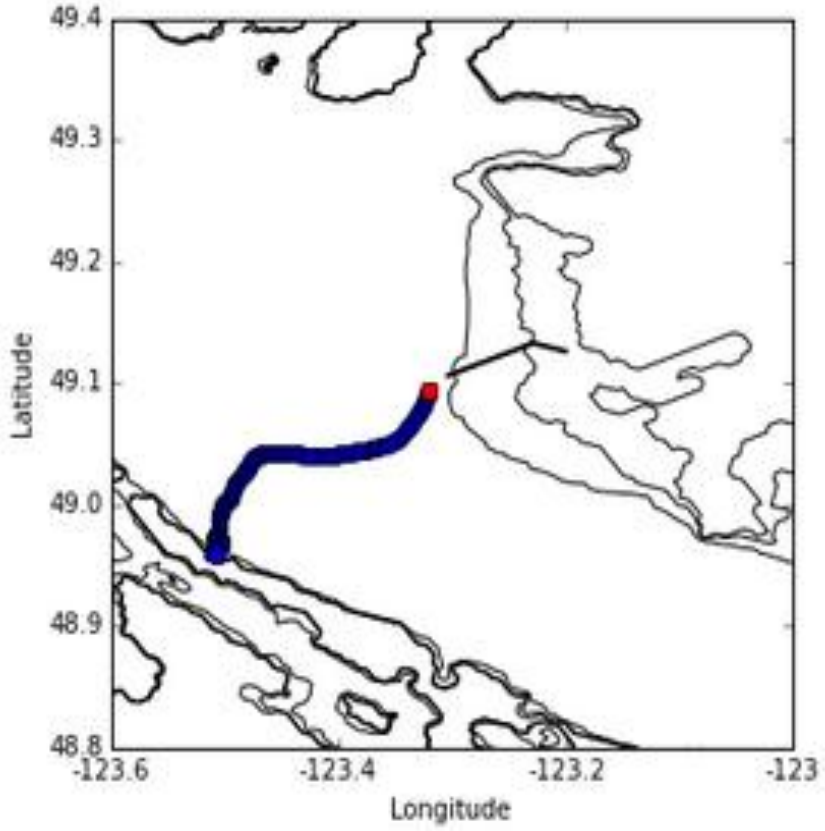
- with/without wind

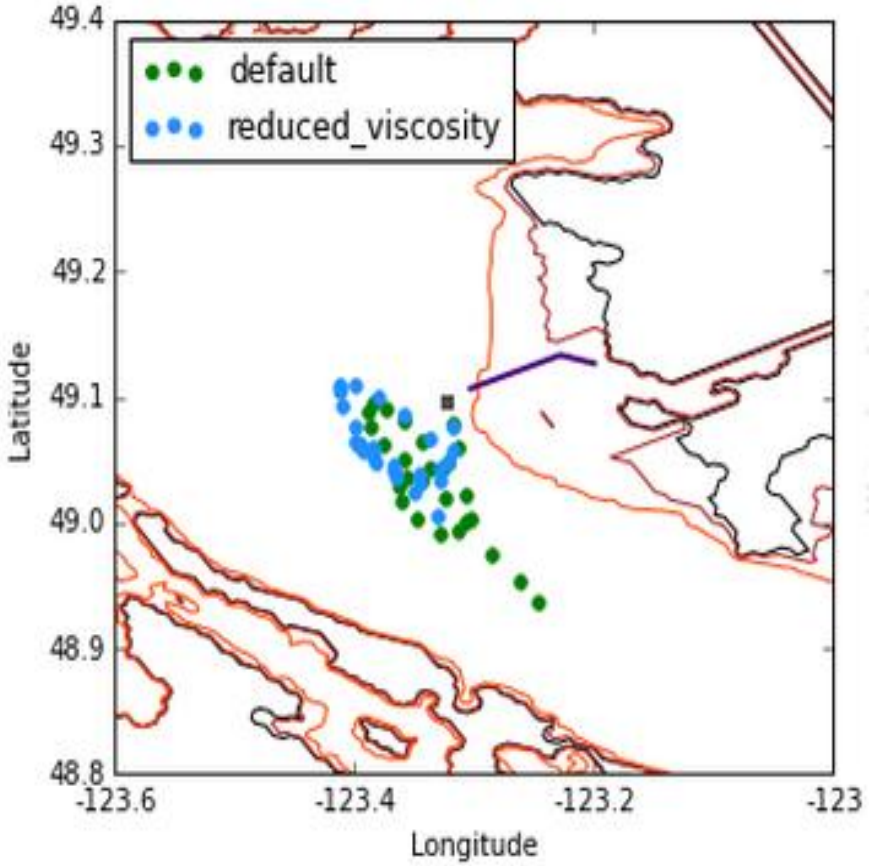




Hindcast comparison

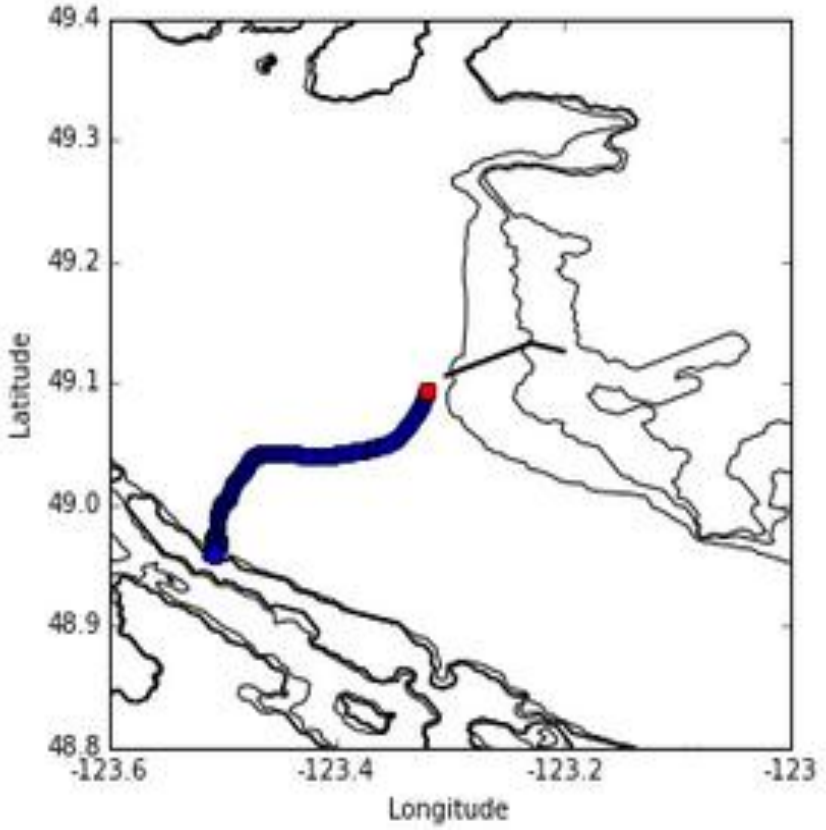
- default/reduced vertical eddy viscosity to $1\times10^{-5} m^2 s^{-1}$

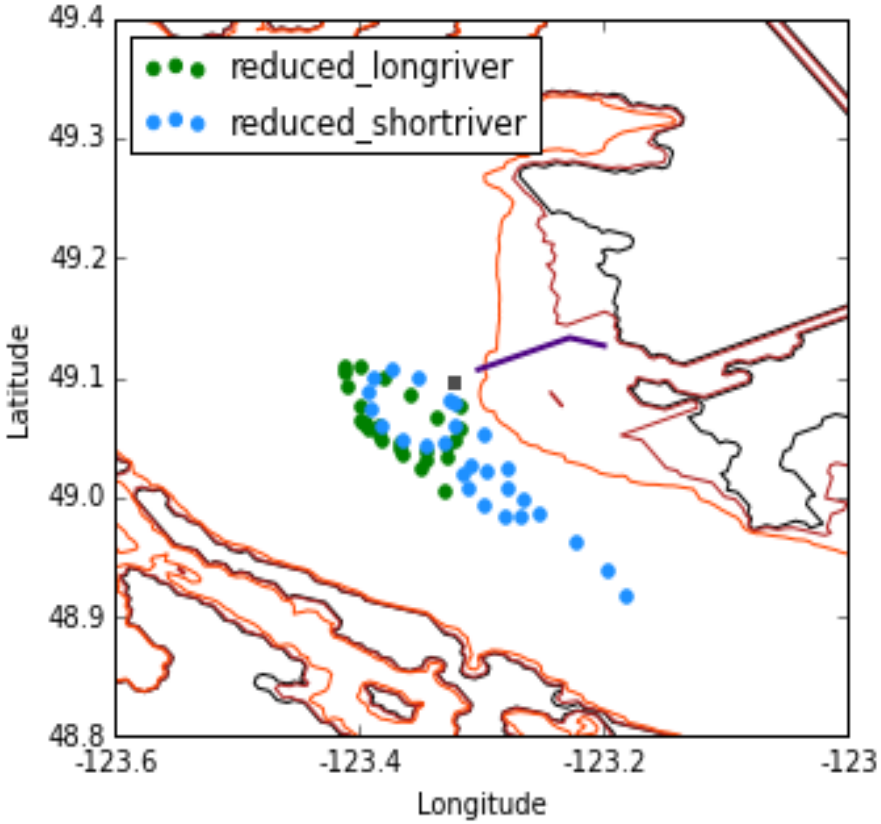




Hindcast comparison

- ***What if using short river channel + reduced viscosity?!***





Summary and future work

- Extended and deepened river channel for Fraser did push water more offshore and pose positive effect on the accuracy of surface currents, which should be added to NEMO 3.6 in the future run.

- Vertical eddy viscosity is an important parameter for plume movement.

- Plume is moving too northward in the model compared with ferry observations, missing jetty should also be included in the model.


Thank you !